2 WILDLAND FIRE MANAGEMENT

Catastrophic wildland fires hit the western United States during the summer of 2002. In 2002, 88,458 fires had affected about 6.9 million acres (www.nifc.gov, 2003). The resulting increase in air pollution from this uncontrolled burning was the equivalent of about 600,000 tons of nitrogen oxides and 1.3 million tons of particulate matter. The estimated economic impact is in the billions of dollars in lost property and economic activity, not to mention losses in ecological value.

The tragic consequences of wildfires have fueled continuing public debate on the issue of preservation, management, and the definition of forest stewardship. As Americans desire to live near the forest, they increase the economic value of property but also the risk to their own safety. They expect their government to protect both. In 2002, the USDA Forest Service (USFS) had spent nearly $1,266 million fighting fires (www.nifc.gov, 2003), but only had $321 million budgeted for the fiscal year, resulting in budget reallocation from other programs.

With both the frequency and severity of fires increasing over the past decade, the recent political response has been the National Fire Plan (NFP), the 10-year Comprehensive Strategy Implementation Plan, the President's Healthy Forests Initiative, and several legislative proposals, most notably HR 1904, the Healthy Forests Restoration Act of 2003. Another recent political development was the Memorandum of Understanding on policy principles for woody biomass utilization for restoration and fuel treatments on forests, woodlands, and rangelands signed by the Secretary of Agriculture, Secretary of Energy, and Secretary of the Interior on June 16, 2003. Forest health, watershed health and public safety issues surround the debate on these plans, which include removing fuel from the forest floors.

The NFP is an interagency action plan for dealing with the many issues surrounding the wildfires. These agencies include the National Association of State Foresters , the United States Department of Agriculture (USDA) Forest Service, the U.S. Department of the Interior's (DOI) Bureaus of Land Management (BLM), Indian Affairs, National Park Service, and the U.S. Fish and Wildlife Service (USFWS). The NFP was initiated after the disastrous 2000 fire season to focus, accelerate, and coordinate activity on reducing fire risks. The NFP is a long-term investment that will help protect communities and natural resources, and most important, the lives of firefighters and the public. It is based on cooperation and communication among Federal agencies, states, local governments, tribes and the interested public. The Federal wildland fire management agencies worked closely with these partners to prepare a 10-year comprehensive strategy, completed in August 2001.

As part of the NFP, the USFS, the BLM, and other DOI agencies are evaluating how to decrease the severity of wildland fires on public lands by reducing excess biomass. Most materials targeted for removal are "ladder trees" or "ladder fuels" that stand from 1 to 40 feet tall, with small diameters typically ranging from 2 to 5 inches at breast height. Downed and dead woody material is not as severe a fire hazard compared to the ladder fuels, which quickly transfer fire to the crowns of larger trees, increasing both the fire's temperature and its potential to spread. Once a fire reaches the crowns, it can travel rapidly and become very difficult to control. Removing these ladder fuels would reduce the severity of a wildfire and give firefighters a greater chance to control it. These ladder fuels are a zero or low value material in the timber industry, but these small diameter trees could be used to produce electric power with significant air pollution avoidance benefits. For example, if the forest thinnings available in uncontrolled burning were instead consumed in power boilers, the nitrogen oxides (NO_x) would be reduced by 64% and particulate matter would be reduced by 97%.

Some environmental activists, however, do not want to encourage a revenue stream based on timber sales, fearing it could create an incentive to cut more trees. Historically, they have taken action to prevent or postpone USFS plans by threatening lawsuits or appeals under the National Environmental Policy Act (NEPA). USFS reports that 48% of mechanical treatment decisions for hazardous fuels were appealed in fiscal year 2001 and through mid-2002. This uncertainty would impact the availability of a steady fuel supply for a bioenergy project based on forest residues or thinnings. Since these are all either administrative proposals or recently introduced legislation, the outcome is uncertain. Clearly, however, this will impact the availability of fuels for bioenergy projects, so project developers and their potential fuel suppliers must continue to monitor developments.

3 THE BIOMASS FEEDSTOCK RESOURCE

This analysis assumes that forest management/wildfire control efforts on United States Department of Agriculture Forest Service (USFS) and Bureau of Land Management (BLM) property will generate approximately 100 tons of thinnings per day from a single forest site. This amount of biomass feedstock can generate approximately 2 MW of power. If the rural utilities choose to combust biomass at higher rates, they will have to either obtain more thinnings from this property or supplement it with other forms of biomass. To minimize additional equipment purchases, the supplementary fuel should be other woody residues; they are obtainable across the country and their similar handling and processing needs make them the least expensive alternative.

This chapter begins with a discussion of the various types, quantities, and locations of woody residues compatible for use in rural utilities. It then provides an overview of other biomass feedstocks that are not geographically confined, such as agricultural residues, energy crops, animal waste, sludge, and tires. By virtue of their widespread location, they offer utilities additional opportunities to use biomass fuel in power generation, if woody residues are unavailable. The chapter also includes a discussion of biomass on public lands. This report does not discuss location-specific biomass resources such as sugarcane bagasse in the southeastern U.S. or walnuts in California because the aim is to outline the most geographically diverse group of resources. Each power production facility will have to evaluate its own unique site and surrounding environment to determine which resources are most viable for its operation.

3.1 Woody Residues

Woody residues include forest thinnings, forest residues, primary mill residues, construction and demolition (C&D) waste, yard trimmings, and other wood wastes. These residue quantities are estimates of *potentially available* supplies,[14] defined as residues that are not currently destined for other productive uses[15]. The implicit assumption is that energy production will not compete for materials already used productively. Bio-energy applications provide another commercial link for utilization of what could otherwise be zero or low value small diameter forest residues. Some markets for commercial forest products would not otherwise exist if the bio-energy end use was not available.

Quantities are provided in megawatts (MW) of equivalent generation, which represent the power generation capacity that could be supported by the residue supply. This shows each residue's electricity generation potential. The MW figures were calculated based on assumptions regarding each residue type's heat content, power plant heat rate, and capacity factor.[16] It is important to note that the MWs represent an upper bound of resource availability—the actual amount of available residue varies by cost. Since the cost of residue is site-specific, and this analysis is meant to provide a snapshot of national biomass resource availability, it is beyond the scope of this report to provide specific MW potential based on fuel cost.

[14] These potentially available supplies were calculated based solely on quantity. Typical biomass supply curves would calculate how much biomass can be supplied at a given price, which is site-specific. Thus, biomass supply curves are outside the scope of this analysis.
[15] An example of a non-productive use would be diverting the residue to a landfill.
[16] The net heat rate is 10,500 Btu/kWh and the capacity factor is 70%, both of which are typical for U.S. coal plants.

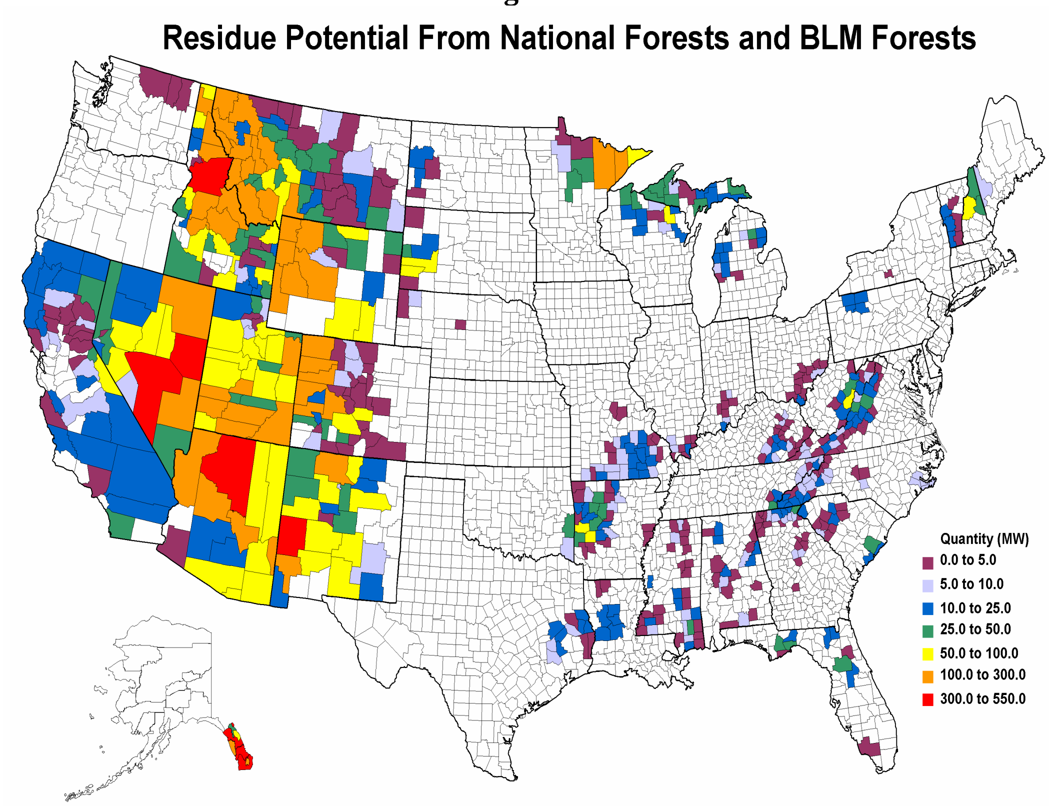
3.1.1 Thinnings

Thinnings are defined as underbrush and saplings less than two inches in diameter plus fallen and/or dead trees. These are also called "ladder fuels" because they accelerate fire's vertical spread. The thinnings referred to in this report are gathered from forests on national forestland and BLM property. Although 100 tons per day of thinnings is not routinely available today, it is presumed that such amounts will be available in the future. Thus, these data represent potential residue availability, assuming that 25% of the forestland is accessible.[17]

Both national forestland and BLM property are concentrated in the western half of the country, and in some stretches across the eastern half. The map below divides the country into counties to show the range of residue potential within each state. Nine states have the greatest potential to generate power from forest thinnings; their counties' power generation capabilities are as follows:

- Nevada (up to 550 MW, with most counties in 50-550 MW range)
- Arizona (up to 550 MW, with most counties in 50-300 MW range)
- Idaho & New Mexico (up to 550 MW each, with most counties in 50-300 MW range)
- Utah & Wyoming (up to 300 MW each, with most counties in 50-300 range)
- Colorado & Montana (up to 300 MW each, with wide variation)
- California (up to 100 MW, with most counties in the 10-25 MW range)

Figure 3-1



[17] Based on analysis done by Antares Group Inc.

In most cases, these states produce a comparable amount of residue from both national forestland and BLM land, except California, where a majority is from BLM land[18], and Wyoming, which does not have any BLM land. Nevada and Utah are the only states all of whose counties are capable of producing thinnings from these lands. Connecticut, Delaware, Iowa, Kansas, Maryland, Massachusetts, New Jersey, and Rhode Island have none of this residue potential within their borders. In Oregon and Washington, this data was not available from the USFS, but it was available from BLM.

3.1.2 Forest Residues

Forest residues are from active forest management (timber stand improvement, or TSI) and commercial logging operations. Forest management practices provide the opportunity to harvest tops and limbs from trees as well as to cull material and salvageable dead trees that were previously left in the forest as waste. The amount of available residues was estimated to be 2.3 tons/1,000 ft^3 of harvested timber. This number was based on information for the Northeast region of the U.S. (C.T. Donovan Associates, 1994). State estimates were calculated by multiplying 2.3 tons/1,000 ft^3 by the amount of harvested timber for each state. This assumes that the relationship between harvested timber and residues is consistent across states (Powell, D.S., et al., 1993).

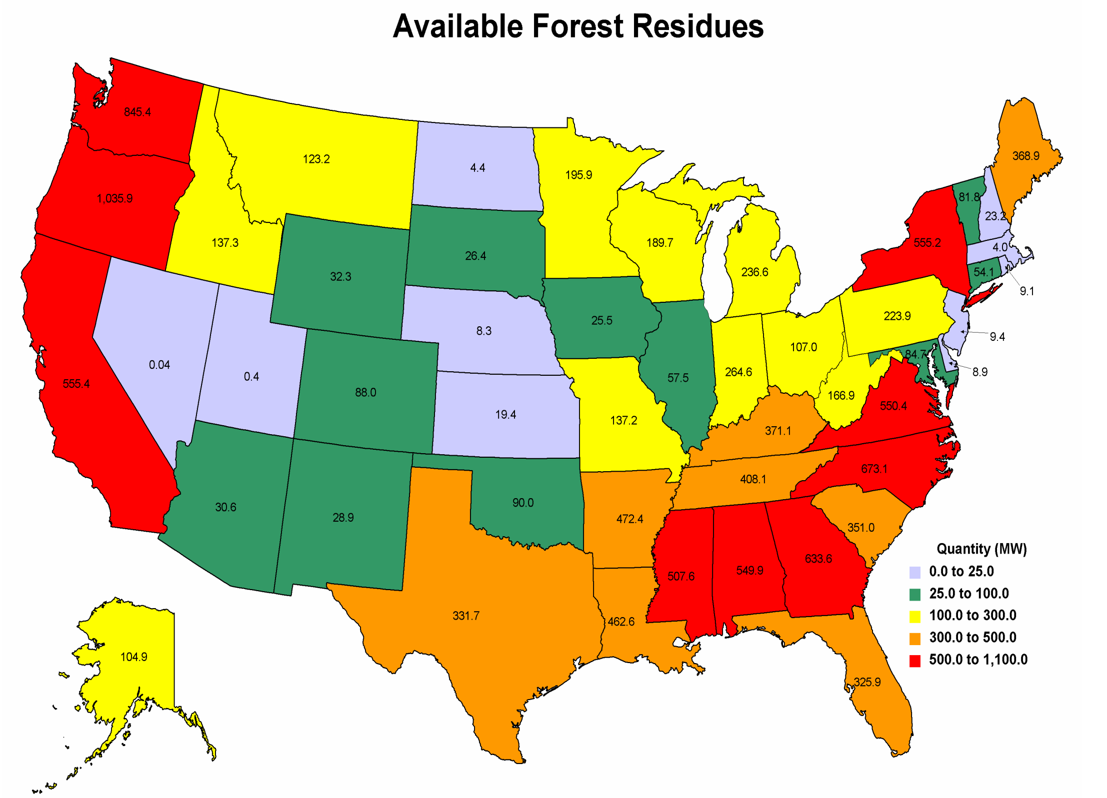
As shown in the following map, these residues are found across the country, with the largest concentrations in the Southeast and West (Antares Group, 1999). Nine states have enough available residue to generate at least 500 MW of power:

- Oregon (1,036 MW)
- Washington (845 MW)
- North Carolina (673 MW)
- Georgia (634 MW)
- California; New York (555 MW each)
- Virginia; Alabama (550 MW each)
- Mississippi (508 MW)

Arkansas, Louisiana, Tennessee, Kentucky, Maine, South Carolina, Texas, and Florida have enough residue to generate from 300 to 500 MW of power and 28 states can generate a minimum of 100 MW.

[18] BLM sell considerably less biomass and/or forest thinnings than the USFS in California.

Figure 3-2



3.1.3 Primary Mill Residues

Companies that use whole logs to create primary wood products (e.g., boards, panels, veneer, beams, pulp) generate primary mill residues. Examples of such companies are sawmills, pulp and paper companies, and other millwork companies. Primary mill residues are usually in the form of bark, chips, sander dust, edgings, sawdust, or slabs; for this report, they are categorized into bark and wood (Antares Group, 1999).

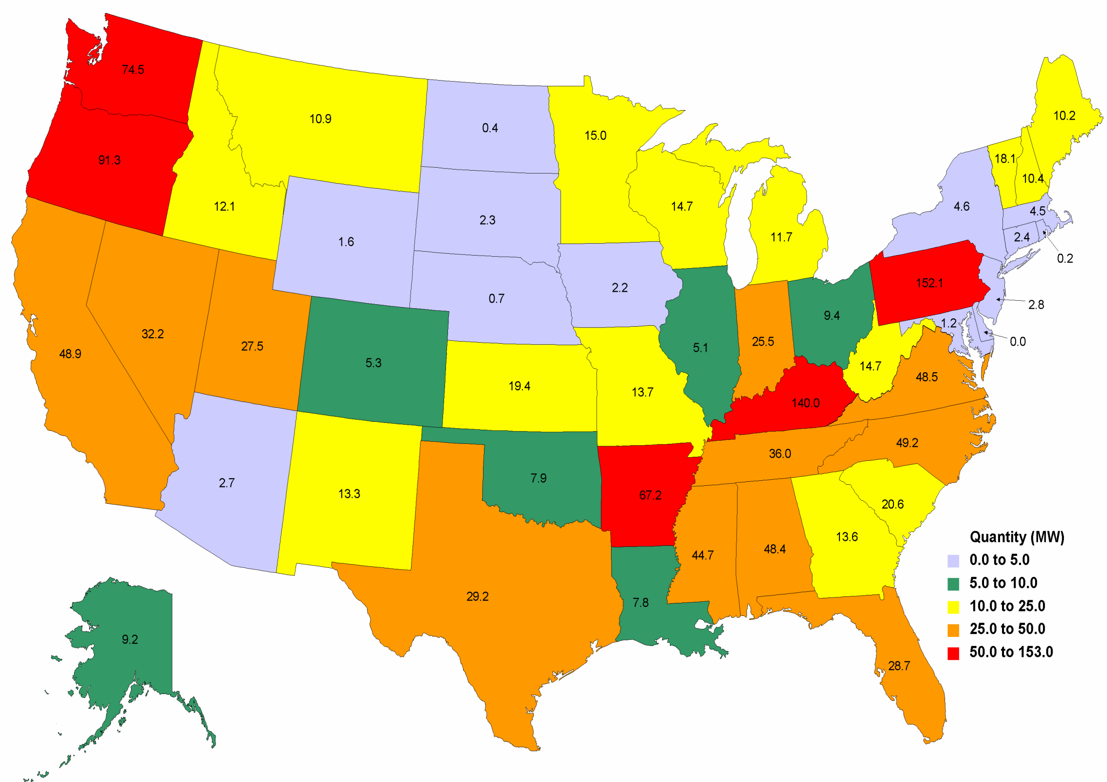
Primary timber mills are large residue producers, but most is used internally, sold, or recycled. It is estimated that 5% of the bark and 6% of the wood residue are available because they are not being used for other purposes (McKeever, D.B., 1998). This assumes that milling practices are consistent across states, so the proportions of these residues per harvested log were assumed to be constant as well. The national estimates for bark and wood primary mill residue are 1.6 million and 5 million tons, respectively. These quantities were apportioned to each state based on its fraction of the total national harvest volume (Powell, D.S., et al., 1993).

The following map shows that the largest concentrations of primary mill residues are in the western and southeastern regions of the U.S. (Antares Group, 1999). Fifteen states can generate at least 25 MW of power from primary mill residues, and 5 states have enough residue to generate more than 50 MW:

- Pennsylvania (152 MW)
- Kentucky (140 MW)
- Oregon (91 MW)
- Washington (75 MW)
- Arkansas (67 MW)

Figure 3-3

Available Primary Mill Residues



3.1.4 Construction & Demolition Waste

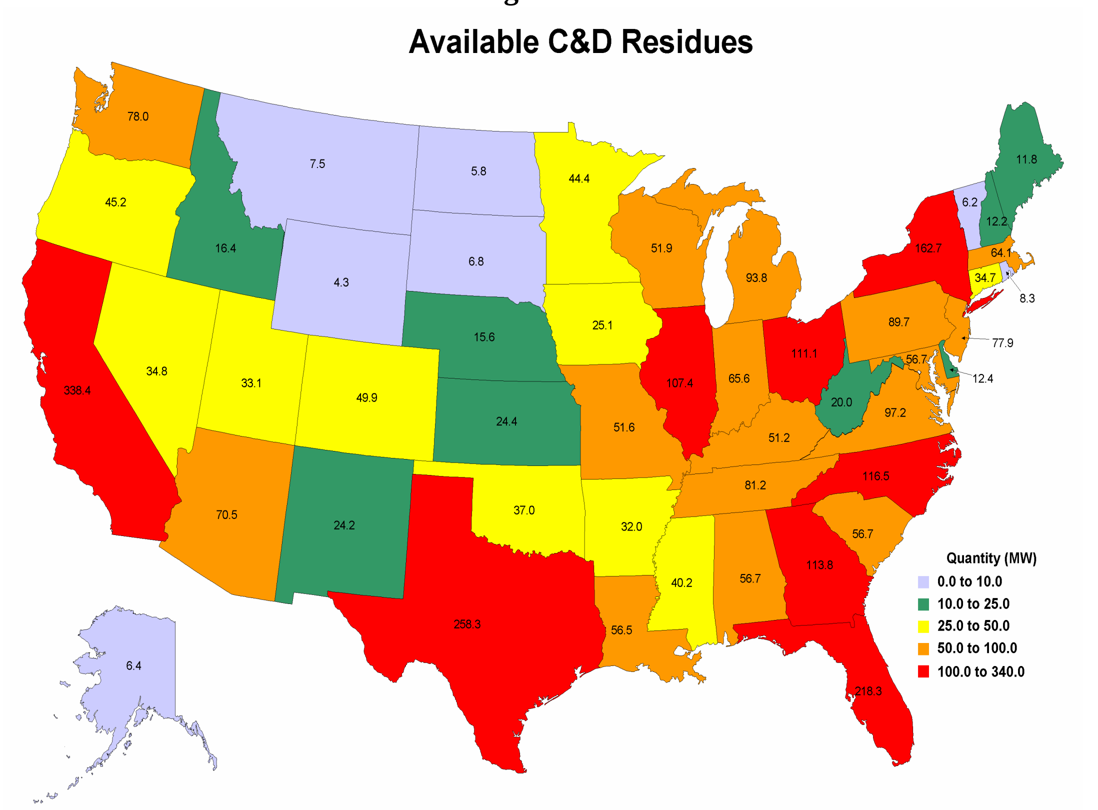
Construction and demolition (C&D) waste is woody material generated from construction and demolition activity. The construction waste discussed in this report is from residential and multifamily building construction (McKeever, D.B., 1998). The total wood used for construction in the U.S. in 1996 was estimated at 67.5 million tons. It is assumed that 90% is placed in new structures and approximately 9% is available for recovery. The average available construction debris for a single-family housing unit is 2.1 lb/ft^2 and for a multi-family housing unit is 1.4 lb/ft^2. The average sizes of single-family and multi-family housing unit are 2,120 ft^2 and 1,066 ft^2, respectively (*Statistical Abstract of the U.S. 1997*). State-by-state quantities of these two types of housing units were used to determine state-level amounts of available woody construction debris.

In 1996, it is estimated that there was 50.4 million tons of demolition debris in the U.S. (McKeever, D.B., 1998). Fifty-two percent was wood and an estimated 30% of that debris was uncontaminated and available for recovery. Thus, about 15.5% (52% x 30% = 15.5%) of the total demolition debris, or 7.8 million tons/year, is available for recovery. This equates to 60 lb/person per year, which was then multiplied by each state's population to derive state-level estimates of demolition debris. The construction and demolition estimates were combined to yield total C&D residue figures for each state.

Since it is correlated with housing and population, C&D waste is available across the U.S., but is concentrated in the more populous states. The map below shows that 24 states can generate at least 50 MW using woody C&D residue, with 8 of them capable of generating at least 100 MW:

- California (338 MW)
- Texas (258 MW)
- Florida (218 MW)
- New York (163 MW)
- North Carolina (117 MW)
- Georgia (114 MW)
- Ohio (111 MW)
- Illinois (107 MW)

Figure 3-4



3.1.5 Yard Trimmings

Woody yard trimmings are an abundant source of wood sent to landfills. In 1996, yard trimmings were the second largest component of the municipal solid waste (MSW) stream, at 29.3 million tons (McKeever, D.B., 1998). In addition to the MSW stream, yard trimmings are also generated from right-of-way trimming near roads, railways, and utility systems such as power lines (DOE/EREN, 2002).

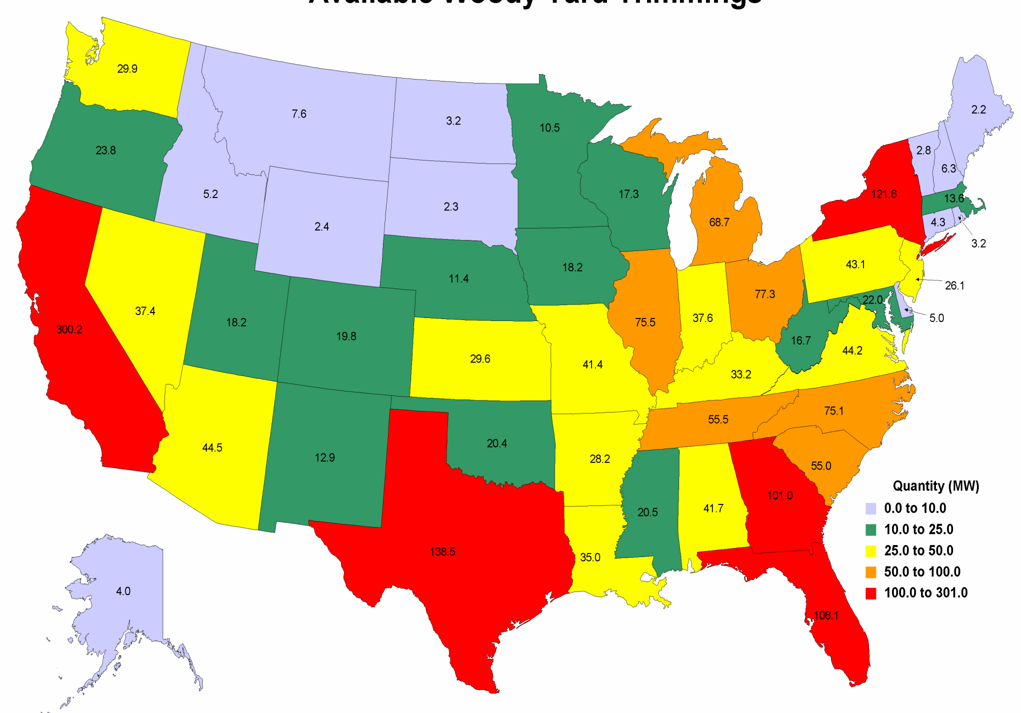
On average, yard trimmings comprise 14% of the MSW stream; it is assumed that 95% of urban tree and landscape residues are wood residues and approximately 36% of those are available for recovery (McKeever, D.B., 1998). Therefore, around 5% of the total MSW stream is available yard trimming residue (14% x 95% x 36% = 5.0%). Each state's landfilled MSW was then multiplied by 5% to obtain its available yard trimmings.

As with C&D waste, yard trimmings are widely dispersed, but are more abundant in populous states. The map below shows that 12 states can generate a minimum of 50 MW from yard trimmings, and 5 can generate at least 100 MW:

- California (300 MW)
- Texas (139 MW)
- New York (122 MW)
- Florida (106 MW)
- Georgia (101 MW)

Figure 3-5

Available Woody Yard Trimmings



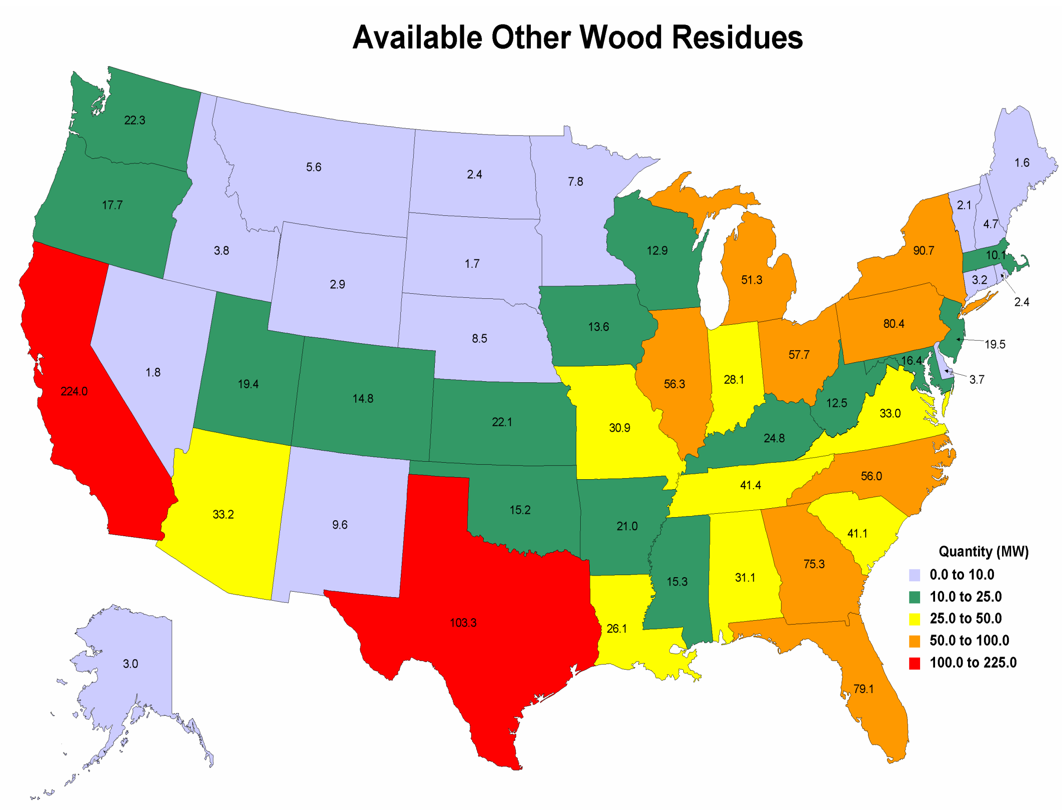
3.1.6 Other Waste Wood

"Other" waste wood comprises discarded consumer wood products and wood residues from non-primary mill manufacturers. This includes discarded wooden furniture, cabinets, pallets and containers, scrap lumber and panels from sources other than construction or demolition, and wood residues from manufacturing activities other than primary wood products mills. Roundwood, unprocessed wood, and repaired or recycled pallets are excluded (Antares Group, 1999).

It is assumed that 7% of the entire MSW stream is wood residue, excluding woody C&D waste and yard trimmings, and that 44% of this amount is available (McKeever, D.B., 1998). To calculate the state-level amounts of "other" waste wood, each state's landfilled MSW total was multiplied by 7% and then by 44%. These percentages were based on national averages and the assumption that the general composition of a state landfill is consistent with the national average and that landfill tipping fees affect each component of the MSW stream equally (McKeever, D.B., 1998). In other words, the tipping fee does not vary by waste stream component.

As shown below, only two states, California (224 MW) and Texas (103 MW) have enough "other" wood residue to generate more than 100 MW. Most other states can generate between 10 and 100 MW of power.

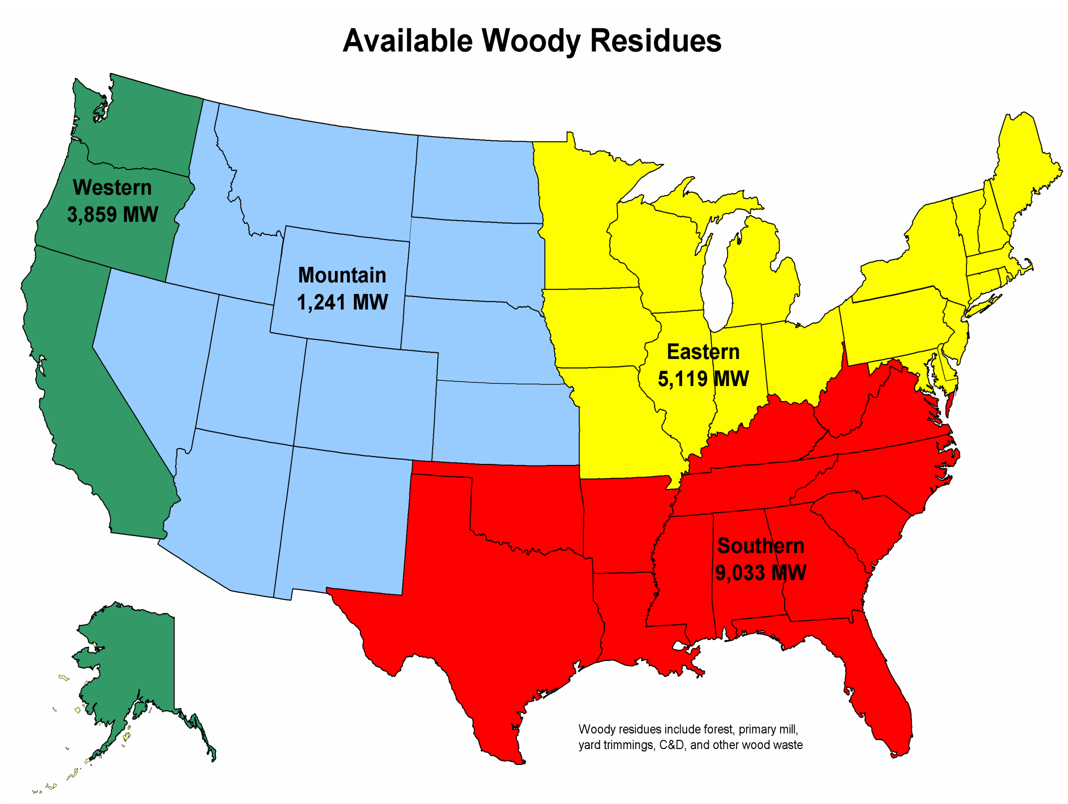
Figure 3-6



3.1.7 Summary of Available Woody Residue Potential

The map and table are a compilation of *potentially available* woody residues discussed in this chapter (forest residues, primary mills, C&D, yard trimmings, and other wood waste). (Antares Group, Inc., 1999) They are expressed in MW of equivalent cofiring capacity. They do not include thinnings because actual quantities are unknown. In terms of biomass resource only, the southern and eastern regions of the country provide the greatest potential for power generation using available woody residues, which gives rural utilities in these areas greater opportunity for biopower projects.

Figure 3-7 *



* These numbers exclude biopower potential from forest thinnings.

Residue Type	Cofiring Potential (MW)
Forest residues	11,594
Primary mill residues	1,156
C&D residues	3,111
Yard trimmings	1,934
Other waste wood	1,457
TOTAL	**19,252**

3.1.8 Biomass Supply on Public Lands

Federal agencies and Congress regularly evaluate the multiple uses of public lands such as outdoor recreation, livestock grazing, mining, and conservation of natural, historical, and cultural resources. With encouragement from Congressional passage of the Bioenergy R&D Act, use of biomass resources is being given increased attention. Severe wildfires during 2000 and 2002 have drawn national attention to managing biomass resources on public lands. One question is whether Federal energy and lands policy could be applied together to enhance the private market for biomass energy and achieve public benefits. This question is being looked at through the recently signed MOU between the DOI, DOE, and USDA, which has increased the federal focus on woody biomass use.

Clearly, the interplay among several public agencies could increase the supply and use of public biomass resources for bioenergy production and thus lower its cost. The Bureau of Indian Affairs (BIA) has a very high interest in developing biomass energy from Tribal and fee lands. Obtaining biomass supplies from public lands will involve either the Bureau of Land Management or the United States Forest Service. Together, these agencies oversee more than 450 million acres of surface lands (compare this to the State of Alaska at about 365 million acres). The DOE, as the nation's principal funding agency for renewable energy research, has significantly funded potential users (power, fuels, or chemical industries) of the public biomass supply. The Environmental Protection Agency (EPA) is the lead regulatory agency in the National Environmental Policy Act process administered by the Council on Environmental Quality (CEQ). NEPA simply requires disclosure and documentation of the environmental effects for a proposed project and provides an informed decision. State, local and regional authorities also participate significantly in public land use discussions.

The Forest Service is a unit of the USDA. It oversees 191 million acres, an area the size of Texas. Originally a division of the Department of Interior but later transferred to USDA, its initial mission was to maintain forest reservations for future generations. By the end of the 19th century, the debate began over actual use and active management of the forests. The USFS mission evolved from preservation to more aggressive sales of timber to one of active use and preservation. Forest management contracts have favored commercial production of board feet through traditional saw timber sales contracts. However, USFS attitudes changed to focus on pre-commercial material removal under the National Fire Plan and the President's Healthy Forests Initiative. Service contracts for removal with an embedded timber sales clause encourage payment for removal of underbrush and payback of a portion of any latter commercial sales. Both ends of the contract are bid competitively.

Award structures are changing from only removing board feet toward more forest stewardship. The most recent Farm Bill designates a stewardship pilot contracting authority. The USFS and BLM can specify how it wants the forest to look and bid 10-year service contracts for cleaning up 20,000 to 30,000 acres of multiple sized materials. The clearing company can then be allowed to sell the material and provide a negotiated amount to the USFS and BLM. Although currently a pilot program, it appears that both a long-term contract (10 years) and a scale in the tens of thousands of acres are favorable terms for biomass power generation contracts.

The BLM, an agency within the Department of Interior, was formed relatively recently during the Truman Administration. It manages more land than any other Federal agency—264 million surface acres. The vast majority (99%) of this land is west of the Mississippi River and in

Alaska. BLM energy resources management has traditionally entailed developing coal, oil, and gas resources. Biomass traditionally has not been part of BLM's energy market mix, instead it is a relatively small portion ($14 million sales in 2000[19]) of BLM's forest product market strategy. (BLM, May 2002). The BLM and DOE, represented by its National Renewable Energy Laboratory (NREL), conducted an analysis to determine biomass supply on public lands. They ranked several BLM planning units for high potential for biomass power development. Most important ranking criteria included sufficient biomass supply within 50 miles of a power plant site, proximity to communities with a skilled labor force, and proximity to "at risk" communities identified in the National Fire Plan as known and favorable to biomass power development. Other important ranking criteria were: land slopes less than 7-12%[20], proximity to existing forest thinning or municipal solid waste facilities, possible livestock protection at site, minimal visual impact, and full cost of competing power known and favorable.

The table below shows where favorable conditions exist for bioenergy development on public lands:

State	BLM Planning Unit
ARIZONA	Arizona Strip, Phoenix, Safford
CALIFORNIA	Alturas, Eagle Lake, Folsom, Redding
COLORADO	Grand Junction, Kremmling, Royal Gorge, San Juan
MONTANA	Butte, Dillon, Missoula
NEW MEXICO	Albuquerque, Las Cruces, Socorro, Taos
OREGON	Central Oregon, Deschutes, Klamath Falls, Lakeview, McKenzie, Swiftwater
WASHINGTON	Wenatchee

3.2 Other Biomass Feedstock

This section discusses the following potential biomass fuels: agricultural residues (corn stover and wheat); switchgrass energy crops; poultry, hog, and cattle manure; sludges from paper mill and wastewater treatment plants; tires; and non-woody municipal solid waste. The economic feasibility of using any of these fuels is site-specific, so they are included in this report only to provide general information on secondary sources of feedstock. As previously stated, although most of these categories can contain a variety of energy-producing fuels, these specific ones were chosen due to their wide geographic availability. Where available, data are provided on feedstock quantities and location.

3.2.1 Agriculture Residues

More than 95 million tons of agricultural waste is generated in the U.S. each year. (DOE/EREN, 2002) The two most abundant crops in the U.S. in terms of average acreage planted are corn and wheat. (Walsh, M.E., et al., 1999) This report only focuses on corn stover (leaves, stalks, and cobs) and wheat straw. Residue quantities were estimated by using grain yields, total grain production, and ratios of residue quantity to grain yield. (Ibid) Quantities that must be left to maintain soil quality differ by crop type, soil type, typical weather conditions, and the tillage

[19] This is total value of BLM's forest products program. The bio-energy portion is less than 1% of this amount.

[20] The NREL analysis underestimated the opportunities in much of California and Oregon, since biomass thinnings can easily be conducted according to DOI on slopes under 30–35%.

system used; estimates were based on a weighted average of all states. It was assumed that 30-40% of the residues could be collected.

The following two maps show the location and MW potential for corn stover and wheat straw that can be delivered at less than $50/dry ton (equivalent to $2.95/MMBtu for wheat straw and $2.88/MMBtu for corn stover).[21] While several states in the central portion of the country can generate power from corn stover, five states in the farm belt section have enough of this residue to generate at least 1,000 MW:

- Iowa (2,840 MW)
- Illinois (2,737 MW)
- Nebraska (1,920 MW)
- Indiana (1,340 MW)
- Minnesota (1,260 MW)

Although more states produce wheat than corn, the country's total MW generation potential is significantly less from wheat straw than from corn stover. In fact, only one state can generate more than 500 MW from wheat straw. Three states have enough to generate at least 250 MW of power at a $50/ton delivered price:

- Kansas (511 MW)
- North Dakota (426 MW)
- Oklahoma (367 MW)

[21] This upper bound value was chosen because, based on assumptions in this analysis, all states can deliver corn stover and wheat straw at less than $50/ton; the national average delivered cost of corn stover and wheat straw is $36/ton (approximately between $2.07 to $2.12/MMBtu). Data based on the 1999 ORNL report, *Biomass Feedstock Availability in the U.S.*

Figure 3-8

Available Corn Stover Residues (< $50/dry ton)

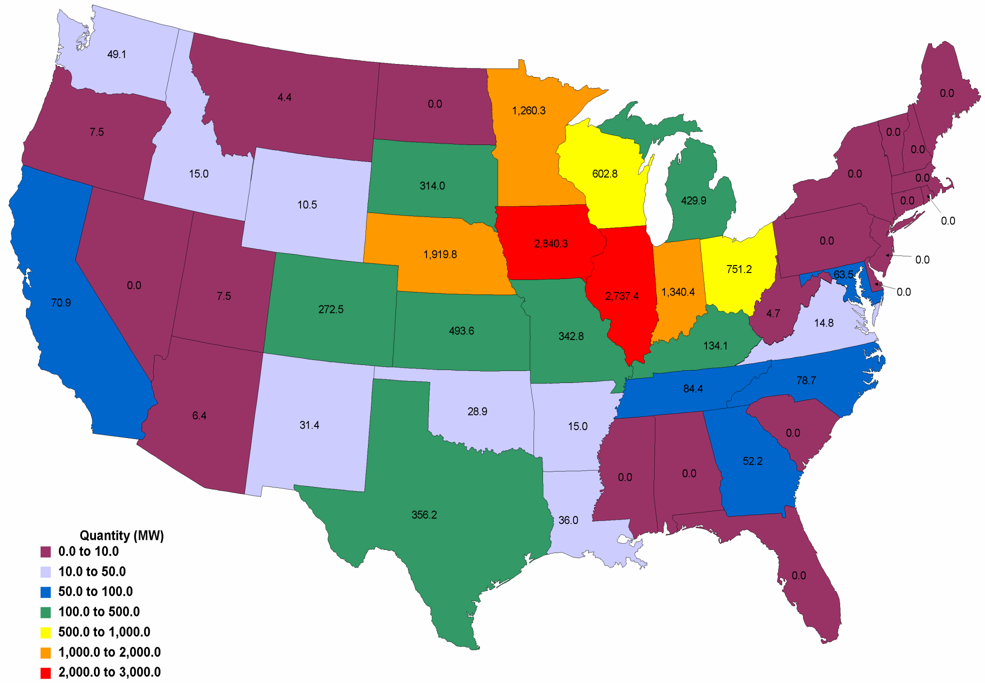
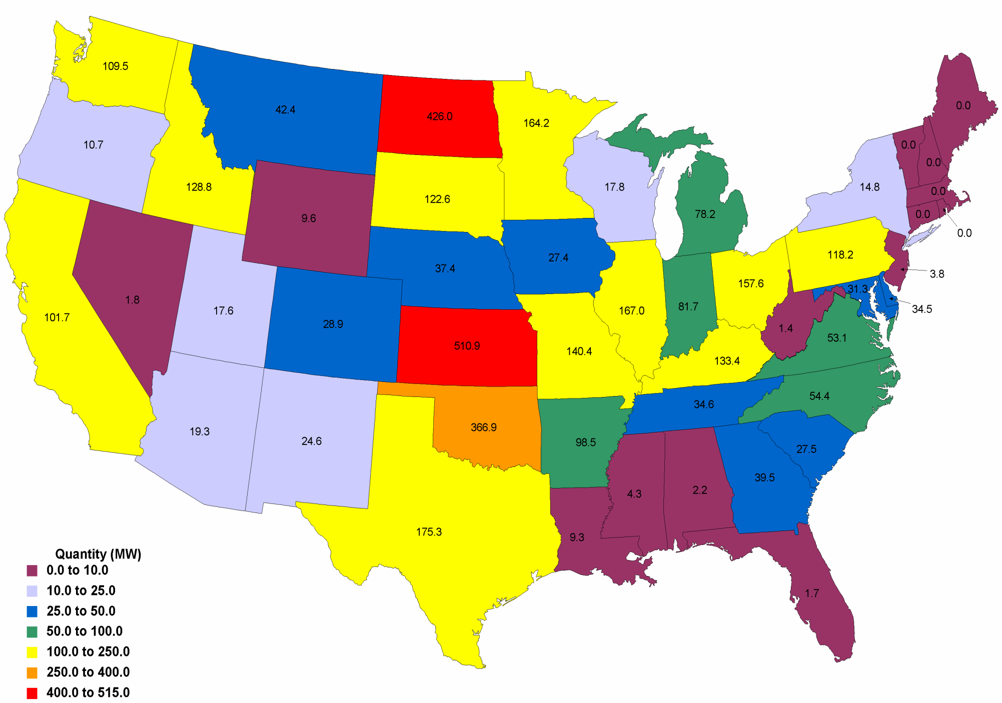


Figure 3-9

Available Wheat Straw Residues (< $50/dry ton)



The primary drivers for converting these "in-field" residues into electricity are avoided fossil fuel purchases and the environmental improvements due to avoided decomposition and open burning practices. The disadvantages to using these residues is crop seasonality, which creates an unsteady and unreliable fuel supply; and competing uses for the residue—corn stover is normally used for animal feed or compost, and wheat straw is used for feed or animal bedding, all of which are established markets.

3.2.2 Energy Crops

Energy crops are crops developed and grown expressly for use as power generation fuel. They are fast-growing, drought- and pest-resistant, and readily harvestable. Energy crops include trees such as poplar and eucalyptus, shrubs, and grasses such as switchgrass. They can be grown on agricultural land not needed for food, feed, or fiber. It is estimated that about 190 million acres of land in the U.S. could be used to produce energy crops. (DOE, 2002) Energy crops provide environmental benefits in the form of carbon sequestration, erosion control, soil remediation, and nutrient filters. Since power plants need fuel on a regular basis, energy crops offer an income benefit to farmers by diversifying their production and by providing a steady revenue stream not affected by fluctuating market demands. (DOE, 2002)

Switchgrass is already used in the U.S. for forage, ground cover, erosion control, and decoration. It is a perennial crop that can grow up to ten feet high and it has an extended root structure, which protects against erosion. It can also be cut and baled with conventional mowers and balers. This section contains switchgrass production data to provide an example of the country's energy crop potential.[22] However, if dedicated energy crops can demonstrate greater revenue generating potential than traditional row crops, the switchgrass can be diverted for use as a power generation fuel.

The estimated quantities of switchgrass are those that can be produced at the same profit level as row crops on the same acres, given the assumed energy crop yield and production costs, and the 1997 USDA baseline production costs, yields, and traditional crop prices. (Walsh, M.E., et al., 1999) As shown in the following map, the largest concentrations of switchgrass residue are in the central portion of the state. At a delivered cost of $50/dry ton (equivalent to $2.81/MMBtu),[23] nine states have enough switchgrass residue to generate at least 1,000 MW of power:

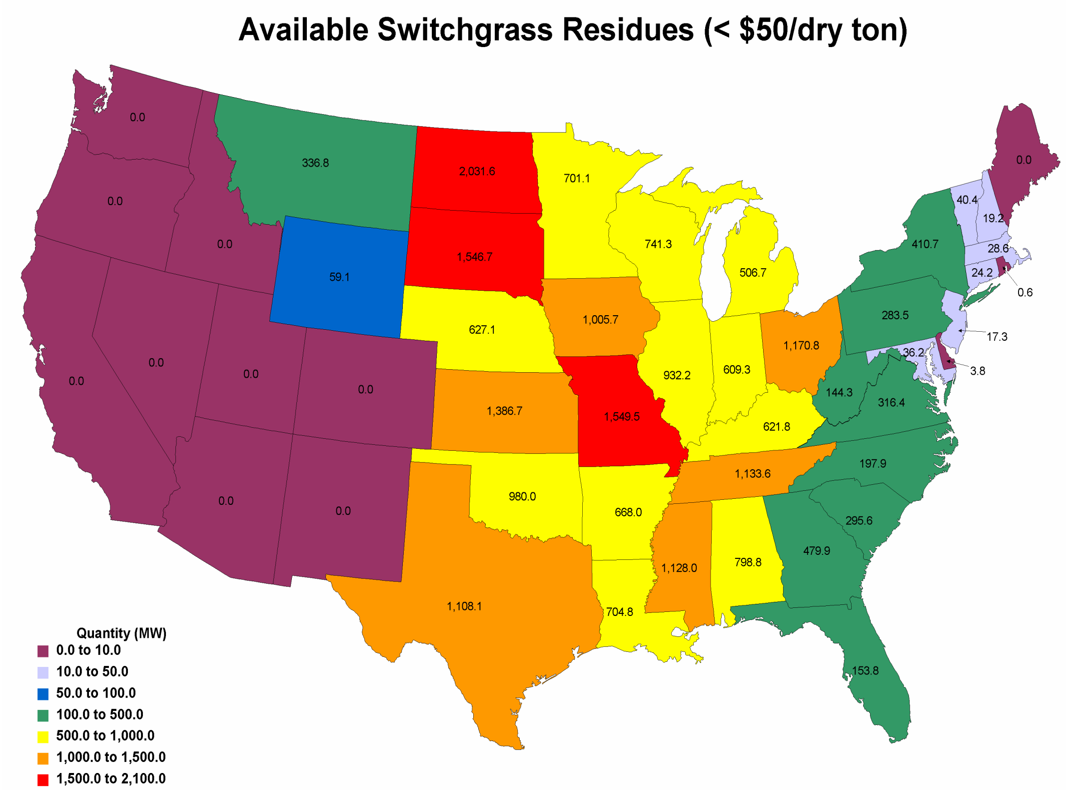
- North Dakota (2,032 MW)
- Missouri (1,550 MW)
- South Dakota (1,547 MW)
- Kansas (1,387 MW)
- Ohio (1,171 MW)
- Tennessee (1,134 MW)
- Mississippi (1,128 MW)
- Texas (1,108 MW)
- Iowa (1,006 MW)

The primary drivers for cultivating energy crops to convert them to electricity are additional farm income and potential environmental improvements. Environmental improvements include soil quality (relative to cultivating traditional crops), farmland preservation, potential water quality

[22] Data on poplar, willow, and eucalyptus are limited or incomplete, so they are excluded.
[23] Based on ORNL's 1999 report, this upper bound value was chosen because all states were found to deliver switchgrass at less than $50/ton; the national average delivered cost of switchgrass is $42/ton.

improvement (energy crops require smaller quantities of herbicides and pesticides relative to conventional crops), and reductions in criteria pollutant emissions from power plants. The disadvantages are relatively higher overall cost, higher-value alternative land uses, added expense associated with harvesting and processing, and farmers' and power plant owners' unfamiliarity with energy crops.

Figure 3-10



3.2.3 Animal Waste

Three types of animal waste are included here: poultry litter (chicken and turkey), hog manure, and cattle manure; their high heating value makes them potential fuel sources. The top five producing states, per animal, are provided below. It is assumed that the states with the largest number of animals will generate the most manure. (EPA, 2001)

- Top 5 <u>chicken</u> producing states (60% of the total)
  - Georgia, Arkansas, Alabama, Mississippi, North Carolina
- Top 5 <u>turkey</u> producing states (58% of the total)
  - North Carolina, Minnesota, Virginia, Arkansas, California
- Top 5 <u>hog</u> producing states (60% of the total)
  - Iowa, North Carolina, Minnesota, Illinois, Missouri

- Top 5 cattle producing states (74% of the total)
  - Texas, Kansas, Nebraska, Colorado, Iowa

- Top 5 dairy producing states (52% of the total)
  - California, Wisconsin, New York, Pennsylvania, Minnesota

The primary drivers for converting animal manures into electricity are reduced disposal costs, avoided fossil fuel purchases, environmental improvements associated with reduced nutrient runoff to local waterways, and reduced odor. The disadvantage is the potential harm to higher-value markets such as fertilizer; currently, manure is used as an inexpensive fertilizer because of its high nitrogen and phosphorous concentration.

3.2.4 Sludge

Sludge is a by-product of paper mills and wastewater treatment plants. Using it as a fuel for electricity is being studied as an alternative option to disposal because it has an energy content and, in the case of paper mills, is available onsite. However, sludge's high moisture content and low overall heating value reduce combustion efficiencies. Paper mill sludge has a 60-65% moisture content and wastewater treatment plant sludge has a 19% moisture content, so it has to be processed before it can be used as a power generation fuel. (Zhao, C., et.al., 1999; Arthur Andersen, 2001) Although some entities currently use sludge as an energy source, it is not recommended for this analysis because it is assumed that it would not be an economically viable fuel for the targeted utilities.

3.2.5 Tires

The volume of scrap tires generated in the U.S. is a substantial portion of the waste stream. Approximately 78% of the estimated 242 million tires discarded annually are dumped, landfilled, or stockpiled. The tires that are diverted from disposal are used to generate energy, to form new products including boat fenders and artificial reefs, and in asphalt to create more durable road surfaces. Energy generation is an attractive option because rubber has considerable energy value—tires contain more Btus per pound than wood, coal, or coke—however, only 11% of scrap tire rubber is used as a fuel. (EPA, 2002) Due to the potentially high cost of gathering and delivering a steady supply of tires and the general public opinion against tire burning, tires are not a recommended resource for the targeted utilities.

3.2.6 MSW

Although woody elements of the municipal solid waste (MSW) stream are included above (e.g., yard trimmings, C&D waste), the remainder of the MSW stream was excluded from this analysis. Despite its ubiquity and significant biomass content, it was not included because of the perceived harm to recycling and reuse markets, negative public perception, potential toxicity and emissions associated with combusting MSW, and the difficulty in obtaining adequately segregated material.

4 RURAL UTILITIES AND OTHER POTENTIAL BIOPOWER OPPORTUNITIES

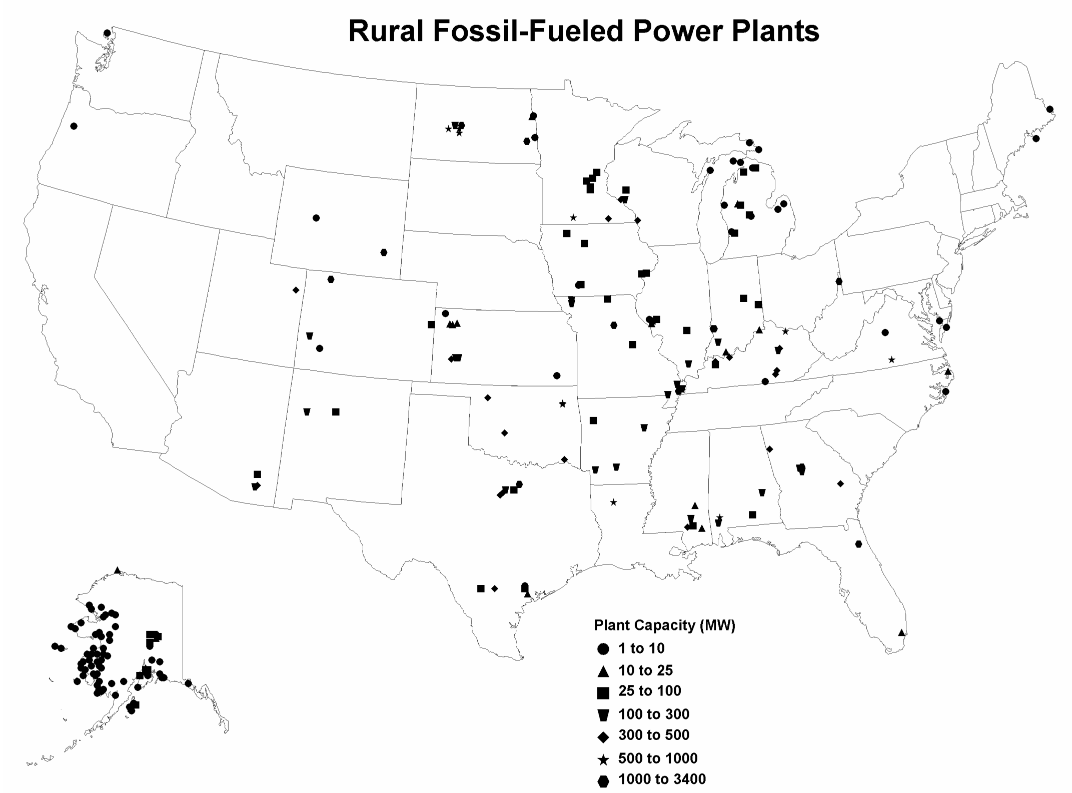
There are a variety of biomass fuels located across the country that are available to the potential biopower production facility. This chapter provides a geographic overview of the rural fossil-fueled utilities and additional power plants that have an opportunity to cofire biomass with coal.[24]

4.1 Fossil-fueled Rural Utilities

The map below depicts the location of rural fossil-fueled power plants, so it includes coal, oil, and natural gas fired facilities. These facilities are located in 32 states, 19 of which have rural coal-fired facilities: Alabama, Alaska, Arizona, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Mississippi, Missouri, New Mexico, North Dakota, Oklahoma, Texas, Utah, Wisconsin, and Wyoming. Of these 19 states, 10 can generate between 200 and 1,000 MW of power and 6 can generate greater than 1,000 MW:

- North Dakota (3,464 MW)
- Missouri (2,440 MW)
- Wyoming (1,710 MW)
- Kentucky (1,455 MW)
- Colorado (1,453 MW)
- Indiana (1,336 MW)

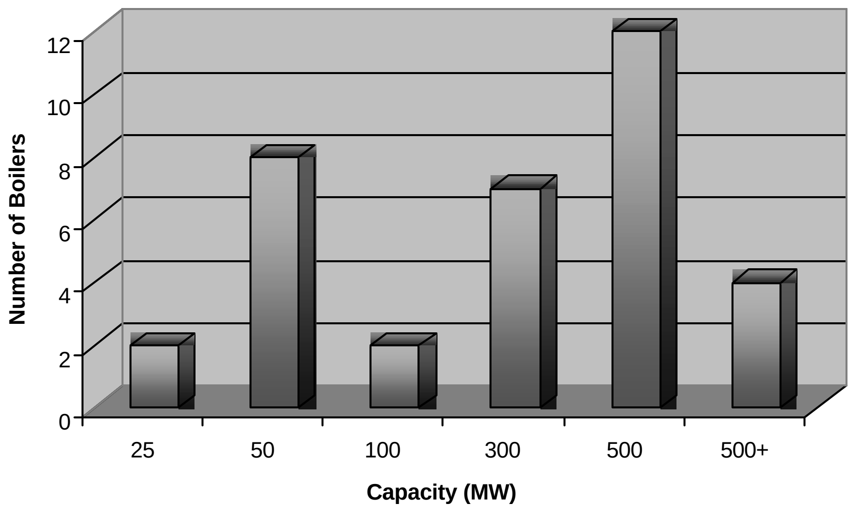
Figure 4-1



[24] Data were obtained from the 2002 *Platt's Directory of Electric Power Producers and Distributors*.

The figure below shows the distribution of coal-fired, rural utility boilers (based on plant capacity data). While boilers of any size can utilize cofiring, the economics and operation improve with larger ratings. There are 24 boilers rated at 100 MW or greater.

Figure 4-2 Rural Utility Boiler Population



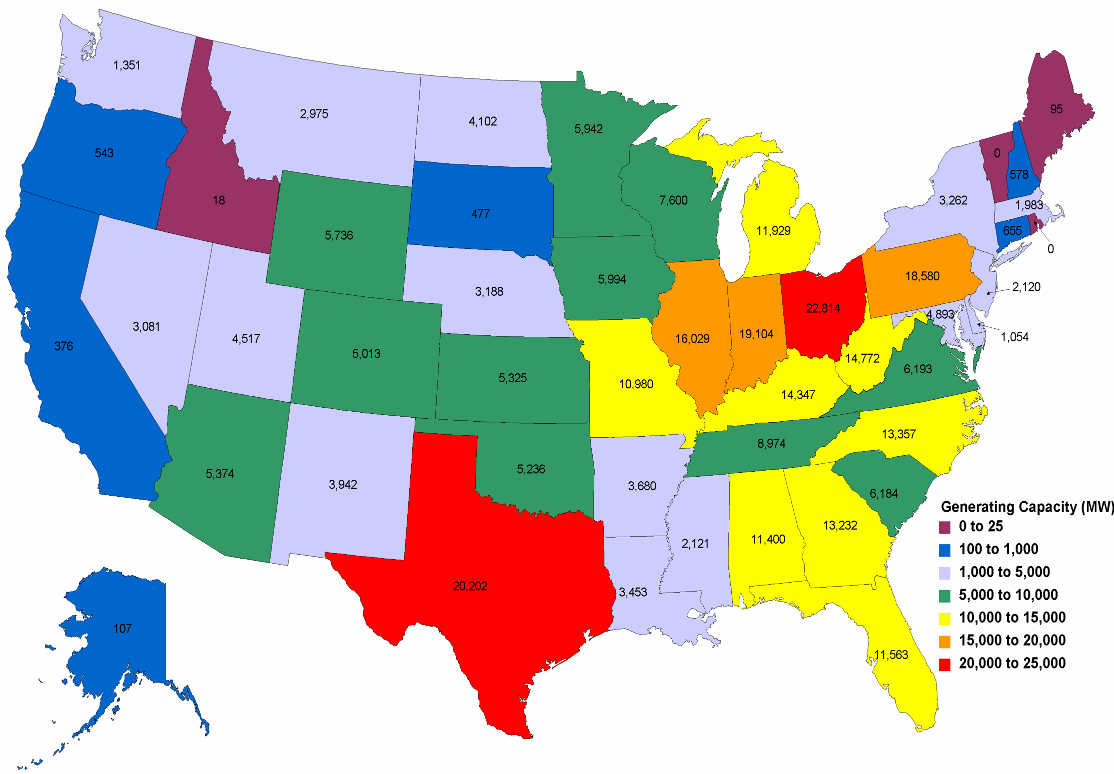
4.2 Other Coal-fired Power Plants

The map below shows the location of utility and non-utility coal-fired power plants. It lists each state's generating capacity in MW. More than 88% of the capacity is from utilities. Thirteen states have the ability to generate at least 10,000 MW of coal-fired power, five of which can generate a minimum of 15,000 MW:

- Ohio (22,814 MW)
- Texas (20,202 MW)
- Indiana (19,104 MW)
- Pennsylvania (18,580 MW)
- Illinois (16,209 MW)
- West Virginia (14,772 MW)
- Kentucky (14,347 MW)
- North Carolina (13,357 MW)
- Georgia (13,232 MW)
- Michigan (11,929 MW)
- Florida (11,563 MW)
- Alabama (11,400 MW)
- Missouri (10,980 MW)

Figure 4-3

Generating Capability of Utility and Nonutility Coal Power Plants



4.3 Federal Facilities

DOE's Federal Energy Management Program evaluated the demand side potential for using biomass. Antares Group Incorporated studied the potential for relatively inexpensive bio mass cofiring at existing Federal facility (FF) boilers. (Antares Group, Inc., 1999) Several ranking criteria were used to identify sites with a high potential for project development:

1) States with FFs that had coal boilers, with steam capacities > 35,000 lb./hr. (boilers that generate power or heat onsite)
2) States with high local biomass resource availability (wood residues)
3) States where FFs face a high cost of delivered coal
4) States with high cost of delivered coal to electric utilities (these utilities may be more willing to replace some coal with biomass)
5) States with favorable regulatory and consumer climates for renewables
6) States with high landfill tipping fees

The screening analysis for that study found high potential for biomass use at Federal facilities in the eastern U.S., Washington State, Alaska. The eastern U.S. ranked high because of the abundance of residue biomass from existing forest products industries, relatively high coal costs, relatively high landfill costs, and number of existing boilers capable of cofiring coal and biomass. The highest-ranked states included: New York, New Jersey, Massachusetts, Connecticut, Delaware, Florida, Pennsylvania, Maryland, New Hampshire, and Washington. Favorable conditions also exist in Virginia, Michigan, Alabama, North Carolina, Tennessee, Georgia, Ohio, and Indiana.